Non-provisional Patent Application of

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For

MARINE RADIAL SURFACE DRIVE

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BACKGROUND

This invention relates to marine drives, that by design operate partially above the water surface. Surface drives exhibit far less drag than their fully submerged counter parts and often used for high speed, marine powerboat competition.

Generally, marine surface drives, or "surface piercing propeller drives", can be divided into two categories; fixed and articulated. Fixed surface drives are stationary elements extending aft of the stern and require a separate rudder mechanism to direct thrust horizontally for directional control as illustrated in U.S. Pat. No. 4,854,903 and 4,689,026. The articulated versions as illustrated in U.S. Pat. No. 6,431,927, 4,790,782, and 4,544,362, has means that allow a drive assembly to move horizontally and/or vertically directing the angle of thrust as needed and generally do not require a separate rudder mechanism.

Disadvantages intrinsic to the "surface piercing propeller drive" are listed below:

(a) Poor reverse or backing performance, attributable to a "cleaver" style propeller design (optimized for surface running).

(b) Propeller-induced side forces, occurring when the top half of the propeller is exposed and a rotational drag of the submerged portion exerts a thrust perpendicular to the direction of forward travel. Large skegs (submerged,

stationary fins) as illustrated in U.S. Pat. No. 5,667,415 and counter rotating propellers as illustrated in U.S. Pat. No. 4,790,782, and 4,544,362, can compensate for these side forces; however, both remedies result in a net increase of drag.

(c) Difficult optimization of engine performance and boat displacement to propeller size. For many this is trial and error. Most boat owners or operators do not have a broad selection of propellers on hand to evaluate. Nor would most have the equipment and time to evaluate many propellers.

(d) Axial instability occurs when a high speed planing boat equipped with a single, "surface piercing propeller drive", is running at high speed in choppy conditions. The propeller induces an erratic thrust in both the forward direction and to a lesser degree, in the lateral direction as the drive encounters various peaks in the chop. The erratic thrust produced in the lateral direction induces a yaw or pitch to the boat. This affects performance and safety.

Various paddlewheel configurations may also be defined as surface drives, however, due to the invention of the "screw type" propeller, few continue to have commercial application. A major disadvantage of the paddlewheel is the necessity to support the drive and most the paddlewheel above the surface. Efficiency is reduced dramatically when the paddlewheel operates with more than 20% of its diameter submerged. This occurs because a fixed paddle or blade produces thrust continuously as it rotates through the water, however, only thrust produced during the deepest part of the rotation efficiently moves the boat forward. A significant portion of available power is consumed accelerating water down ahead of the paddle wheel and lifting water up aft of the paddle wheel.

Attempts to produce more efficient and consistent thrust with a paddlewheel through the use of articulated blades have been tried as illustrated in U.S. Pat. No. 5,297,933, and 2,258,699. These patents and others like them, solve part of the problem by optimizing the contact angle of each paddle or blade relative to a desired direction of force, however the blade or paddle velocity parallel to this line of force is non-linear. Blade velocity (in the direction of the desired line of force) at a point where the blade crosses the horizontal

centerline of the paddlewheel rotation is zero. In contrast, the blade velocity (in the direction of the desired line of force) at a point where the blade crosses the vertical centerline (at the bottom of the rotation) is at maximum and equals the rotating velocity of the paddlewheel. As a result, the blades seem work against themselves. This problem becomes more pronounced when the paddlewheel is deeply submerged. For purposes of calculating available thrust of a given paddlewheel, an engineer must average the blade velocity as a function of its operating depths and the rotating velocity.

Many of the articulated designs of the prior art achieved the articulation through the use of complex planetary gear arrangements. These would be costly to build relative to a screw type propeller of similar thrust and would be difficult to maintain in a marine environment. In addition, it could be speculated that the friction loss through complex gear arrangements would offset any gains the inventor may have claimed. The large rotating masses associated with the planetary gear arrangements would prevent these designs from being used in a modern competitive powerboat environment.

Other commercial disadvantages of the paddlewheel include; large drive systems relative to screw type propellers, poor handling due to a flat blade design, and an obsolete stigma. The disadvantages of the paddlewheel have limited it to resort-style pedal boats and historic vessels, operating in relatively calm inland waters.

The obsolete paddlewheel, however, has inherent advantages over the "surface piercing propeller drive" such as the absence of propeller-induced side force and low relative drag possibilities.

Objects and Advantages

The marine radial surface drive of the present invention exploits the advantages inherent in the paddle wheel and has several objects and advantages which are:

(a) to provide a radial surface drive that is simple to manufacture and operate and has wide commercial utility;

(b) to provide a radial surface drive with controlled and consistent thrust from a "paddle wheel" configuration;

(c) to provide a radial surface drive of a "paddle wheel" configuration which is relatively small compared with traditional paddlewheels and can be transom mounted in a conventional manner ;

(d) to provide a radial surface drive with good reverse capabilities;

(e) to provide a radial surface drive which does not have a lateral or side force like a "surface piercing propeller drive";

(f) to provide a radial surface drive without appendage drag;

(g) to provide a radial surface drive with the ability to trim the boat (alter the vertical angle of delivered thrust) while underway;

(h) to provide a radial surface drive with the ability to limit the magnitude of delivered thrust while underway;

(i) to provide a radial surface drive that by design is open, and easy to inspect and service;

(j) to provide a radial surface drive that is stable under extreme acceleration because the rotation of the drive is radial and not axial;

The marine radial surface drive of the present invention combines known paddlewheel and surface drive concepts with several unique features. The result is a design that is versatile and easy to manufactured with current knowledge and machinery.

As will be seen in the drawings, one example of this, is the unique blade shape and profile which is a major contributor to the overall performance of the surface drive of the present invention. The curved shape of the blades cause them to function under load like turbine vanes, delivering thrust throughout the submerged portion of a rotation much more efficiently than flat blade designs. Two discrete curves are visible in each blade's profile, these allow for efficient operation at multiple depths and provide stability in choppy waters.

A slight concave curve is featured along each blade's axial plane, which provides lateral stability under acceleration.

Another unique feature is the placement of an eccentric cam within the blade support cylinder. This "load cam" allows the tip velocity of the blades to be controlled and regulated during the submerged portion of the rotation. The shape of the cam allows the thrust delivered by the drive to be tailored to suite boat displacement and engine efficiency. By changing the position of the cam, the blade's tip velocity and angle can be changed while the boat is underway. Cams with different profiles can be exchanged to suite specific applications or power improvements of a given boat.

Further objects and advantages will become apparent from a consideration of the ensuing description and drawings such as the articulated drive support and shroud. These features are essential to the preferred embodiment, which is a design optimized to replace stern drives within existing boat designs and configurations.

The versatility of the present invention allows for a variety of configurations including; twin drives with a single inboard engine, and twin drives with two inboard engines. As will be seen in the ensuing drawings, boat designs can be engineered around the radial surface drive in a highly stylized manner.

SUMMARY OF THE INVENTION

It is the purpose of this invention to provide a surface drive, which affords the competitive and commercial advantages of the "surface piercing propeller drive", while eliminating the inefficiencies and instabilities associated with propeller induced side forces. Furthermore, it is the purpose of this invention to provide a radial surface drive that by design, allows an operator of a boat so equipped with said drive, to actively control and adjust the relative magnitude, angle and elevation of the thrust delivered by said drive.

The radial surface drive of the present invention is lightweight, easy to fabricate, and requires low maintenance. The present invention may be made from corrosion-resistant

materials such as brass, stainless steel, aluminum, and composites to extend the useful life of the apparatus.

The radial surface drive of the present invention has useful application within marine powerboat competition, as well as many useful leisure and/or commercial applications.

A marine radial surface drive of the present invention does not use a screw type propeller operating upon an axial rotation. Instead, such apparatus comprises a plurality of articulated blades of unique shape, affixed to a central hub operating upon a radial rotation. In the present invention, the radial surface drive is affixed to a drive axle that is perpendicular to the centerline or keel of the boat and is secured within an adjustable support member extending aft of a transom and above the surface. A cam within the drive's hub manipulates the angle of the blades during a selectable portion of a rotation and is controlled by the operator. In the preferred embodiment, the aft support member pivots vertically at the transom; hydraulic actuators affixed to the transom and the support member allow operator control of the vertical elevation of drive. In the preferred embodiment, a rudder assembly is attached to the trailing end of the support member. A shroud encloses the forward portion of the drive for safety as well as decreasing blade cavitation at high speeds through aeration. These features are not combined in any known prior art.

DRAWINGS

Drawing Figures

In the drawings, closely related figures have the same number but different alphabetic suffixes.

Fig. 1 shows a plan view of the preferred embodiment showing only the transom of a boat with an inboard engine with a reference to section drawing Fig 4.

Fig. 2 shows the side elevation of the preferred embodiment with a reference to section drawing Fig 3.

Fig. 3 shows the section referenced in Fig. 2.

Fig. 4 shows the section referenced in Fig. 1.

Fig. 5 shows an exploded view of the preferred embodiment.

Fig. 6 shows an exploded detail of a blade and it's various parts with a reference to section drawings Fig 7a and 7b.

Fig. 7a and 7b shows blade sections along the radial and axial plane respectively.

Fig. 8a and 8b shows an isometric view of the preferred embodiment with a transparent illustration of the boat and drive components.

Fig. 9a shows an "at rest" or "idle" detail of the blades, support cylinder, load cam and cam actuator, as viewed from the left side with a dashed line representing the theoretical waterline.

Fig. 9b shows the same components illustrated in Fig. 9a with 12 blade positions shown at 30-degree points of a given revolution at low to moderate boat speeds with a dashed line representing the theoretical waterline.

Fig. 9c shows the same components illustrated in Fig. 9a with 12 blade positions shown at 30-degree points of a given revolution at moderate to maximum boat speeds with a dashed line representing the theoretical waterline.

Fig. 9d shows the same components illustrated in Fig. 9a with 12 blade positions shown at 30-degree points of a given revolution in reverse with a dashed line representing the theoretical waterline.

Fig. 10 shows a schematic illustration of the hydraulic control system.

Fig. 11a and 11b show isometric views of an alternate embodiment.

Fig. 12a and 12b show isometric views of another alternate embodiment.

Reference Numerals in Drawings

1 blade support cylinder	2 blade
3 actuating lever assembly	4 load cam
5 axle	6 support member
7 bearing carrier	8 pulley
9 bearing	10 clip
11 hex nuts	12 washer & bolt
13 clip grooves	14 Radial Surface Drive
15 transmission	16 drive pulley
17 lower structural connection	18 upper structural connection
19 hydraulic ram – trim	20 drive belt
21 rudder assembly	22 hydraulic ram – load cam position
23 pin	24 hull outline
25 hydraulic ram – rudder position	26 bolts
27 drive shaft	28 shroud
29 hydraulic lines	30 engine
201 torsion spring	202 hinge pin
203 actuating lever	
300 friction reducing element	301 pin
302 retainer	303 sealed bearings
400 steering wheel	401 N/A
402 trim and thrust control	403 N/A
404 control valve (steering)	405 control valve (trim)

DETAILED DESCRIPTION

Description-Figs. 1 through 2-Preferred Embodiment

A top and side view of the preferred embodiment of the present invention is illustrated in Figs. 1 and 2 respectively. An adjustable member **6** supports a radial surface drive **14**, and a rudder assembly **21**. A pair of conventional hydraulic actuators **19** is operably connected between the support member **6** and a transom of a boat **24** and provides vertical support and trim control. Contracting or extending the actuators **19** in a conventional manner will alter the rearward elevation of the support member **6** as shown in Fig. 2. A single conventional hydraulic actuator **25** is operably connected to a rudder assembly **21** such that contracting or extending the actuator **25** in a conventional manner, will alter angle of the rudder assembly **21** as shown in Fig. 1. A conventional hydraulic actuator **22** is operably connected to a load cam **4** such that contracting or extending the actuator **22** in a conventional manner, will alter the position of the load cam **4** as shown in Figs. 9a, 9b, 9c and 9d. Conventional hydraulic lines **29** provide a high-pressure, flexible-connection between hydraulic actuators **19**, **22**, and **25**, and a boat's conventional hydraulic control system as illustrated in Fig. 10. Structural connections **17** and **18** provide pivotable attachments for the support member **6** and actuators **19** respectively. These connections are formed of cast aluminum, however, any material with suitable strength and corrosion resistance can be used. Conventional stainless steel, press-fit pins **23** operably connect structural connections **18**, to actuators **19**. Said pins **23** operably connect actuators **19** to integrated tabs of support member **6.**

Fig. 3-Preferred Embodiment

This section illustration is referenced in Fig. 2. It illustrates the placement of the load cam **4** within a blade support cylinder 1 and the arrangement of the load cam **4**, a bearing carrier 7, a pair of conventional sealed, precision bearings **9**, and conventional clips **10**, along an axle 5. The axle **5** is fixed and does not rotate, however, minimal fore and aft movement is provided by adjustable journals to allow for tension adjustment of a conventional drive belt **20**. Axle **5** is formed of stainless steel and has 5 grooves **13** at predetermined locations to receive conventional clips **10** and machine threads at each end to receive a bolt and washer

12. Clips **10** align the load cam **4**, and bearings **9** of the bearing carrier **7**, such that load cam **4** is centered within the cylinder **1**. The bolt and washer **12** operably secure axle **5** to the support member **6**. Load cam **4** is operably connected to hydraulic cylinder **22** and can pivot within a 150-degree range upon axle **5**. The load cam **4** is formed of forged aluminum with a brass insert bearing at the point of contact with axle **5** and a thin PTFE strip covering the load surface cam **4**.

A conventional transmission assembly **15** is suitably mounted to the transom **24** and receives a rotational energy from an engine **30** (not shown). A drive shaft **27** exits the transmission **15** on axis of the support member **6** pivot point, and forms the attachment pin on the right side of the support member **6**. Operably attached to the drive shaft **27** is a conventional drive pulley **16**. A conventional pulley **8** and drive pulley **16** are matched in width and pitch with drive belt **20** and are suitable for the rotational energy applied. Pulley **8** and pulley **16** are operably connected by belt **20**. Pulley **8** and **16** diameters can be changed to alter the final drive ratio. Pulley **8** and drive pulley **16** are formed of forged aluminum, however, any material with suitable strength and corrosion resistance can be used.

Bearings **9** support a pivot point within structural connection **17** on the right side of support member **6**. The structural connection **17** located on the left side does not have a bearing and uses a conventional press-fit pin **23**. The left pivot point of support member **6** has a brass insert bearing with a greasable fitting.

Support cylinder **1** has an offset integral hub. Both the cylinder **1** and the hub are formed from aluminum, however, any material with suitable strength and corrosion resistance can be used. The diameter and width of cylinder **1** is sized according to boat size and available power. The outer surface of cylinder **1** is smooth and uniform and has provisions for six-identical, hinged blade configurations as illustrated in Fig. 6. Each hinge provision is equally spaced around the perimeter of the cylinder **1** as illustrated in Fig. 4, and is comprised of segmented aluminum tubing welded to the outer surface of the cylinder **1**.

Fig. 4-Preferred Embodiment

This section illustration is referenced in Fig. 1, and shows a side view of the placement of load cam **4** within the blade support cylinder **1**. The radial surface drive of the present

invention is presented with six blades **2**, however, boat size and type will predetermine the number and size of the blades **2**.

A shroud **28** encloses the radial surface drive of the present invention. As illustrated in fig. 4, the shroud **28** is comprised of two components; a stationary component attached to transom **24** using a marine adhesive or other suitable means, and a larger interlocking component operably attached to support member **6** with conventional stainless steel fasteners. This view illustrates the interior of shroud **28,** which is a shape similar to a parabola. This shape allows blades **2** to accelerate air within shroud **28** and aerate blades **2** as they enter the water, thus reducing problems associated with cavitation. As presented, the sections of shroud **28** is formed of a conventional composite material and can be shaped and colored in a manner consistent of the boat to which it is installed, however, the shroud can be formed of any material with suitable strength, corrosion resistance and operating characteristics.

Fig. 5-Preferred Embodiment

Fig. 5 shows an exploded, isometric view of the preferred embodiment. As presented, the support member **6** is comprised of two components connected with convention stainless steel bolts **26**. Not shown in Fig. 5 is the shroud **28**, hydraulic lines **29**, and engine **30**.

Fig. 6, 7a and 7b-Preferred Embodiment

Fig. 6 shows an exploded, isometric connection detail for 1 of the 6, blades **2** of the preferred embodiment. Each blade **2** is configured to match the respective hinge provision of cylinder **1** and is pivotably coupled with a hinge pin **202**. The blades **2**, and the hinge pins **202** are formed of stainless steel, however, any material with suitable strength and corrosion resistance can be employed.

Said blades **2** have in common; an actuating lever **203,** and a friction-reducing element **300**. The levers **203** are attached to the back of each blade **2** by welding or other suitable means and have a mass and length that is specific to the boat application. Less mass and length on said lever **203** extends the responsiveness of cam **4** into higher rpm ranges. The lever **203** must operate through a respective opening provided in the cylinder **1**. The

friction-reduction element **300** of the preferred embodiment is comprised of a pair of conventional sealed precision bearings **303**, a pin **301**, and a retainer **302**. The bearing pair **303**, sandwich the end of the actuating lever **203**. A space is provided within the hinge segments of each blade **2** to allow the placement of a pair of torsional springs **201** on pin **202**.

Said blades **2** also have in common; a specific profile as illustrated in Fig. 7a and a cross-section as illustrated in Fig. 7b. Both features are concave with respect to the blade **2** fronts. The radius of each feature is specific to utility of the radial surface drive of the present invention. The radius of the concave features illustrated in Fig. 7a are 1.5 times the height of blade **2** and the radius of the concave feature illustrated in Fig 7b substantially equals, 2.5 times the width of blade **2**. These radiuses may be slightly different for different applications. In general terms, higher boat velocities, which require greater horsepower and associated drive rpm, requires less curve in the concave features of the blades.

Fig. 8a and 8b-Preferred Embodiment

Fig. 8a and 8b show isometric views of the assembled radial surface drive of the preferred embodiment looking through a transparent transom. Fig. 8a provides the configuration of the structural connections **17** and **18**, and the relative placement of the transmission **15**. This view also shows a conventional splined input shaft of the transmission **15**. To simplify the drawing, the engine **30**, a coupling to the transmission **15**, and hydraulic lines **29** are not shown. In Fig. 8b a ghost view of the drive **14** is visible through various components.

Fig. 9a, 9b, 9c, and 9d-Preferred Embodiment

These figures are operational in nature and will be discussed in the following "Operation" section.

Fig. 10-Preferred Embodiment

Fig. 10 shows a schematic illustration of the hydraulic control system. The hydraulic system includes a conventional power source **406** such as an electric motor suitably coupled

to a conventional hydraulic pump **408**. A conventional hydraulic fluid reservoir **407** and conventional 4-way and 2-way control valves **404** and **405** respectively, are suitably connected to pump **408**. Trim actuators **19** and load cam actuator **22** is connected to control valve **404** by hydraulic lines **29**. Rudder actuator **25** is suitably connected to control valve **405** by separate but similar hydraulic lines **29**. Valve **405** is suitably connected to a conventional steering wheel **400** of the boat in a conventional manner while valve **404** is operably connected to a conventional, 4-way joystick type lever **402**. Rotation of steering wheel **400** operates valve **405** thus controlling the flow of pressurized hydraulic fluid from pump **408**, through lines **29**, which will cause the extension or contraction of hydraulic actuator **25**. In this manner rudder assembly **21** will pivot horizontally left or right as shown in Fig 1. Movement up or down of lever **402** operates valve **404** thus controlling the flow of pressurized hydraulic fluid from pump **408**, through separate lines **29**, which will cause the extension or contraction of hydraulic actuators **19**. In this manner the support member **6** and all attached components will move up or down. Movement left or right of lever **402** operates valve **404** thus controlling the flow of pressurized hydraulic fluid from pump **408**, through separate lines **29**, which will cause the extension or contraction of hydraulic actuator **22**. In this manner the load cam **4** will pivot upon the axle **5**.

Figs.-11a and 11b-Alternate Embodiments

Figs. 11a and 11b illustrate a stylized application of the present invention. Fig. 11a illustrates a catamaran or "tunnel hull" style boat designed to optimize a pair of radial surface drives driven by a single engine. In this embodiment the power transfer is accomplished through the use of a conventional transmission and differential assembly. A single centered rudder would be employed with separate trim and thrust controls for each drive. The shrouds are shown as integrated, stationary hull elements. In Fig. 11b a ghost view of the drives is visible through various hull components.

Figs.-12a and 12b-Alternate Embodiments

Figs. 12a and 12b illustrate another stylized application of the present invention. Fig. 12a illustrates a competition style boat designed to optimize a single radial surface drive driven by a single engine. In this embodiment the power transfer from engine to the drive is

accomplished through the use of a conventional belt and pulley assembly. The transmission has been reduced to a simple a clutch allowing the operator to engage or disengage the engine from the belt assembly. The engine is installed transversely. The shroud as shown is an integrated, stationary hull element. In Fig. 12b a ghost view of the drive is visible through various hull components.

Advantages

From the description above, a number of advantages of my marine radial surface drive become evident:

(a) The radial surface drive will operate well rotating in a reverse direction. To this end I will offer that the quantified reduction of the drive's performance in the reverse direction should be minimal and irrelevant when compared to a boat's quantified reduction of performance moving in the reverse direction.

(b) The radial surface drive by design, has no associated lateral forces. This yields three advantages;

1) all available power produced by a boat's engine can be transferred to forward thrust,

2) the elimination of the skegs needed to overcome the lateral forces as seen in "surface piercing screw type propellers" of the prior art, results in less appendage drag, and

3) greater lateral stability a planing speeds, particularly in choppy conditions.

(c) The ability to alter the drive's elevation while underway allows the operator to control the ride angle (trim) of the boat. This allows the use of the radial surface drive on high speed planing hulls where trim angle is critical to overall performance. Paddlewheels of the prior art have not have been commercially used on high speed planing hulls.

(d) The load cam as described above is unique. In the finite terms of rotation, it allows

each blade to release its load early as seen in Fig. 9b. or hold it longer as seen in Fig. 9c. When used in conjunction with the elevation adjustment, of the present invention, the amount of thrust released or held can be altered. This allows an engines most efficient RPM to used for almost any boat speed or laden weight. This is discussed in greater detail in the "Operation" section.

(e) The shroud allows the moving parts of the drive to be enclosed for purposes of safety without diminishing performance.

(f) The shroud improves performance by providing an enclosed space whereby the blades (accelerated by the load cam near the point of rotation where the blades enter the shroud), accelerate and pressurize air within the cavity behind each blade as it enters the water. During boat acceleration, this insures a volume of air behind each blade that is at a pressure equal to: or greater than: atmospheric, thus eliminating cavitation that could otherwise create vibrations that rob power and damage blades.

(g) Even with the inherent flexibility of the radial surface drive as described above, damage and wear will preserve the need to replace blades. An operator or owner can stand on a dock and with the drive raised, remove a pin and change the blade. The blades can be removed easily without removing the boat from the water.

Operation

The operation of the radial surface drive of the present invention can be simplified into four general modes of operation. These modes are;

(a) Idle-drive **14** is operating 0 to 200 rotations per minute (rpm)

(b) Cruising-drive **14** is operating within the 200 to 1800 rpm range

(c) Maximum-drive **14** is operating with full power applied

(d) Reverse-drive **14** is operating at idle in the reverse direction of rotation.

The rpm ranges as stated are for purposes of discussion and should be taken as such. Different boats of different applications will have distinctly different needs in terms of thrust, for example, a race or competition only vessel may never operate, of have capacity within its equipment to operate, in the reverse mode.

The idle mode, as shown in Fig. 9a, illustrates the relationship of the blades **2**, support cylinder **1**, load cam **4** and hydraulic actuator **22**, as viewed from the left side with a dashed line representing the theoretical waterline. Other items have been omitted for purposes of simplifying the drawing.

An operator of a boat, floating on a body of water, having conventional controls. Further equipped with a conventional engine **30**, transmission **15**, and transom **24** and so equipped as to begin traveling in a forward direction, would place the engine's **30** controls at idle and transmission **15** in neutral and start engine **30** in a conventional manner. Activating power source **406** can now employ the boat's hydraulic system. The operator moves lever **402** up causing valve **404** to allow high-pressure fluid to flow from pump **408**, through lines **29** into the ram side of cylinders **19**. This causes cylinders **19** to contract, thus raising drive **14**, rudder assembly **21** and attached components, above the surface of the water. The operator moves lever **402** left, causing a separate section of valve **404** to allow high-pressure fluid to flow from pump **408**, through separate lines **29** into the ram side of cylinder **22**. This causes cylinder **22** to contract, thus pivoting cam **4** clockwise (when viewed from the left). These movements place drive **14** at a maximum elevation above the surface of the water, and at a minimum thrust capability.

The operator now places transmission **15** in forward in a conventional manner, causing drive shaft **27** to turn pulley **16**, associated drive belt **20** and pulley **8**, thus rotating contiguous elements, bearing carrier **7**, and drive **14** about axle **5**. The operator moves lever **402** down causing valve **404** to allow high-pressure fluid to flow from pump **408**, through lines **29** into the piston side of cylinders **19**. This causes cylinders **19** to extend thus lowering drive **14**, rudder assembly **21** and attached components, into the water. The boat begins slow forward movement. The distance drive **14** is lowered is a function of laden weight and desired rate of acceleration. The operator considers these variables when selecting the optimum drive elevation.

As illustrated in Fig. 9a, load cam **4** is in a full clockwise position. This cam position allows blades **2** to fold back under significant load at approximately the vertical centerline crossing at the bottom of the rotation. However, torsional springs **201**, contiguous to each hinge, apply a counter force which is sufficient to transfer a small amount of rotational energy into forward thrust by maintaining blades **2** in a substantially extended position at low rpm.

At this point, if the operator increases the rpm of engine **30** thus increasing the rpm of drive **14** proportionally. The load at each blade **2** will exceed the counter force applied by springs **201** thus causing blades **2** to fold back when the force encountered when making contact with the water is applied. Therefore, the operator must move cam **4** into position prior to increasing engine **30** rpm.

The cruising mode begins when an increase of forward velocity is desired. Fig 9b illustrates the left side view of the relationship of blades **2**, support cylinder **1**, load cam **4** and hydraulic actuator **22**, for this mode, with a dashed line representing the theoretical waterline. The operator moves lever **402** right, causing valve **404** to allow high-pressure fluid to flow from pump **408**, through lines **29** into the piston side of cylinder **22**. This causes cylinder **22** to extend, thus pivoting cam **4** counter-clockwise. This places cam **4** at a position whereby contact between cam 4 and element **300** begins to occur at an early point of the sub-surface rotation of drive **14**, whereby blades **2** do not fold back when said force is applied. The operator increases the rpm of engine 30 in a conventional manner, thus increasing the rpm of the drive **14** proportionally, thus increasing thrust produced by drive **14**, thus increasing the forward velocity of the boat proportionally.

The operator may decide the bow of the boat is riding high for the given conditions and weight distribution within the boat. Moving lever **402** such that, cam **4** is rotated clockwise, or drive **14** is lowered slightly, or both can remedy this. In the cruising mode, both of these actions will have an effect on the relative elevation of the bow (trim).

The operator will monitor engine **30** rpm, forward speed, and trim of the boat. The operator will adjust the elevation of drive **14** and position of cam **4** such that the thrust delivered by drive **14** is suitable for optimum engine rpm and boat speed for the given

conditions.

The maximum mode of operation begins anytime the operator of the boat desires maximum thrust or boat acceleration. This situation may be brought about through marine competition, adverse weather conditions, or other water sport activities. The steps are the same as discussed earlier, however, the emphasis is to transfer maximum power to the water rather than optimized cruising efficiency.

The maximum mode begins when the maximum forward velocity and rate of acceleration is desired. Fig 9c illustrates the left side view of the relationship of blades **2**, support cylinder **1**, load cam **4** and hydraulic actuator **22**, for this mode, with a dashed line representing the theoretical waterline. The operator moves lever **402** right, causing valve **404** to allow high-pressure fluid to flow from pump **408**, through lines **29** into the piston side of cylinder **22**. This causes cylinder **22** to extend, thus pivoting cam **4** fully counter-clockwise. This places cam **4** at a position whereby contact between the cam 4 and element **300** begins to occur at an early point of the sub-surface rotation of drive **14** and continues somewhat past the vertical center line. This maximizes the time blades **2** can produce usable thrust. The operator increases the rpm of engine **30** in a conventional manner, thus increasing the rpm of drive **14** proportionally, thus increasing thrust produced by drive **14**, thus increasing the forward velocity of the boat proportionally. The rapid acceleration can elevate the bow slightly, as a result, the operator may decide to run drive **14** deeper than normal to compensate for this.

At very high rpm the mass and length of lever **203** contribute to performance. This occurs because the weight of lever **203** increases as a function of centrifugal velocity and begins to resist a portion of the load on the blade independently. This feature buffers the movements of blades **2** during the transition of load as the position of cam **4** is altered during high-speed operation and as blades **2** to move from air to water. This is a unique feature and key attribute of the radial surface drive's performance in high-speed applications.

The reverse mode of operation begins when the operator decides to reverse the direction of forward travel or to begin travel in the reverse direction. Fig. 9d illustrates the left side view of the relationship of blades **2**, support cylinder **1**, load cam **4** and hydraulic

actuator **22**, for this mode, with a dashed line representing the theoretical waterline.

The reverse mode can be employed at any submersed drive **14** elevation or cam **4** position. During counter rotation, force is applied to the back of blades **2**, as a result, actuating lever **203** is applied against the inner surface of cylinder **1**. This enables the blades **2** to remain fully extended under load and prevents conflict between element **300** and cam **4**.

The operator of the boat, floating on water, so equipped as to begin traveling in a reverse direction, begins the reverse mode with engine **30** operating and its controls at idle, transmission **15** in neutral and drive **14** approximately 20% submerged. The operator places the transmission **15** reverse in a conventional manner. Thus causing drive shaft **27** to turn pulley **16**, associated drive belt **20** and pulley **8**, thus rotating contiguous elements, bearing carrier **7**, and drive **14** about axle **5** in a clockwise direction when viewed from the left. The boat begins slow reverse movement. The distance drive **14** is lowered is a function of laden weight and desired rate of reverse velocity. The operator considers these variables when selecting the optimum drive elevation. At this point, the operator can increase the rpm of engine **30** thus increasing the rpm of drive **14** proportionally, as needed.

Conclusions, Ramifications, and Scope

Thus, the reader will see that the marine radial surface drive of the present invention provides a simple, efficient, and stable alternative to the "screw type propeller surface drives" and "paddlewheels" of prior art. The drive as presented, is versatile, and easily serviced and manufactured. Furthermore the radial surface drive has the additional advantages in that:

- it can to be raised or lower by the operator while underway to match the boat conditions and performance needs;
- the blades of the drive have a unique curve that provide efficient and stable thrust;
- the blades of the drive have a unique mass upon actuating lever that buffers blade movement thus reducing vibration at high rpm:
- the blades of the drive have a unique torsion spring on the hinge that buffers blade

movement thus reducing vibration at low rpm:

- the angle of the blades can be altered while underway by the operator thus allowing the angle and magnitude of thrust delivered by the drive to be adjusted;
- the design of the drive provides good reverse characteristics;
- the shroud of the drive provides a safety cover as well as improving performance by reducing cavitation;

the drive does not induce lateral force during operation and

- can be made from many different materials.

While my above description contains many specificities, these should not be construed as limitations on the scope of the invention, but rather as an exemplification of preferred embodiments thereof. Many other variations are possible such as:

(a) A radial surface drive with suitably coupled outboard engine affixed to an articulated support suitably attached to the transom of a boat., whereby steering is brought about by the pivot of the engine and drive upon said transom support.

(b) A boat equipped with one or several radial surface drives and an electronic, programmable logic controller that is suitably connected to; load, tachometer, thermometer, position, pressure and velocity sensor input devices. In addition said controller suitably connected to output control elements specific to hydraulic actuators 19, 22, and 25, such that, the efficient operation of the boat is a matter of automated and pre-programmable input/output functions.

Accordingly, scope of the invention should be determined not by the embodiments illustrated, but by the appended claims and their legal equivalents.